SAFETY REGULATION OF INNOVATIVE NUCLEAR INSTALLATIONS IN THE RUSSIAN FEDERATION: CHALLENGES AND SOLUTIONS

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The objectives of the presentation are to specify challenges in licensing of Russian innovative nuclear installations and to address new/revised safety rules and regulations aimed at improving safety regulation of nuclear research installations (NRIs) in the Russian Federation.

- NRIs to be addressed:
  - neutron beam high flux reactor PIK
  - multipurpose fast research reactor MBIR
  - experimental-industrial nuclear technological complex Argus-M
Federal Rules and Regulations in the Field of Nuclear Energy Use (FRRs)

- General safety regulations (22)
- Nuclear power plants (28)
- Nuclear research installations (11)
- Floating nuclear facilities (7)
- Other (33):
  - Fuel Cycle Facilities (16);
  - Radiation Sources (4);
  - Radwaste Management (12);
  - Space vehicles with nuclear reactor (1)

FRRs - 101
Safety Guides - 139
Safety Rules and Regulations for NRIs

- General Safety Provisions for NRIs (NP-033-11);
- Nuclear Safety Rules for Research Reactors (NP-009-17);
- Nuclear Safety Rules for Pulse Reactors (NP-048-03);
- Nuclear Safety Rules for Critical Stands (NP-008-16);
- Nuclear Safety Rules for Subcritical Stands (NP-059-05);
- Requirements to the Contents of NRI Safety Analysis Report (NP-049-17);
- Provisions on Procedure for Investigation and Accounting of Operational Events at NRIs (NP-027-10);
- Requirements to the Content of Plan of Actions to Protect Personnel in Case of an Accident at NRI (NP-075-06);
- Safety Rules for NRIs Decommissioning (NP-028-16);
- Periodic Safety Review of Nuclear Research Installations (NP-092-14).
Safety Benchmark for NRIs

General Safety Provisions for NRIs (NP-033-11)

- safety benchmark
- probability of maximum accidental release $10^{-7}$ in the interval of one year

When the target indicator is reached, it is necessary to evacuate the public outside the protective action planning zone and take additional measures to manage the beyond design basis accident in order to mitigate its radiation consequences. The benchmark encourages improved safety for the NRIs.
Federal Rules and Regulations under Development/Revision

Currently:

• Requirements to the Content of Plan of Actions to Protect Personnel in Case of an Accident at NRI, NP-075-19 – revision.
• Provisions on Procedure for Investigation and Accounting of Operational Events at NRIs, NP-027-xx – revision.

To be revised by 2021

• Requirements to the Contents of NRI Safety Analysis Report, NP-049-17.
Innovative Nuclear Research Installations (1/6)
Neutron Beam High Flux Reactor PIK

* thermal power – 100 MW;
* tank type, water-water reactor with coolant under pressure 5 MPa;
* fuel – uranium dioxide (UO2), uranium enrichment 235U 90%.


First physical start-up – February 2011, power level was not above allowed 100 W.

The resumption of reactor power operation in mid-2018 after a long shutdown.

The power start-up program and the commissioning program are three stages of reactor power development: 100 kW, 10 MW, 100 MW.
Innovative Nuclear Research Installations (2/6)  
Neutron Beam High Flux Reactor PIK - Licensing Challenges

• December 2018 - changes were made to the conditions of the operation license of the PIK NRI, allowing the installation to operate at power levels up to 100 kW (reached in early 2019).

• A possibility to amend the license conditions to operate at power levels up to 10 MW is now under consideration.

• Associated safety related issues:
  - radiation safety;
  - implementation of the resource management program of the safety important systems and the justification of the design life;
  - hydrogen explosion safety;
  - ensuring control of metal equipment and pipelines;
  - certification of software;
  - measures for management of beyond design basis accident;
  - control of metal of the equipment and pipelines;
  - certification of basic equipment, including equipment manufactured abroad.
Innovative Nuclear Research Installations (3/6)  
Multipurpose Fast Research Reactor MBIR

* thermal power – 150 MW;
* electrical power – 55 MW;
* fuel – mixed uranium-plutonium MOX;
* primary and secondary coolants – sodium, tertiary coolant (turbine circuit) – water / steam.

2014 – siting license (expired on 25.07.2019);
2015 – construction license (until 08.05.2025);
2018 – by decision of the strategic council of State Corporation Rosatom, first criticality of MBIR is postponed to 2024; commissioning of the reactor is scheduled for 2030.
Innovative Nuclear Research Installations (4/6)  
Multipurpose Fast Research Reactor MBIR – Licensing Challenges

Unresolved technical issues of the safety case at the construction stage:

• incomplete designs and safety cases for the loop installations;
• incomplete justification of the function and characteristics of the new fuel composition (MOX fuel);
• incomplete justification of the design life of 50 years.
Innovative Nuclear Research Installations (5/6)
Pilot Industrial Nuclear Technological Complex Argus-M

* thermal power – 50 kW;
* fuel – aqueous solution of uranyl sulfate with low enrichment up to 20%;
* intended to implement innovative technology for production of medicine radioisotopes, including Mo-99.

Frequency of fuel replacement – 1 time in 10 years.
Reactor service life – 30 years.

Rostechnadzor is currently reviewing the applications for siting and construction of the Argus-M complex.
Innovative Nuclear Research Installations (6/6)
Pilot Industrial Nuclear Technological Complex Argus-M – Licensing Challenges

Further safety demonstration at the construction stage should be carried out on the following issues:

• determination of the distribution of radiolytic gas bubbles inside the fuel solution, which is one of the most important issues of hydrogen explosion safety;

• certification of the computer codes designed to study the neutronic and thermal-hydraulic systems;

• analysis of the time-dependent processes and transients (such as failure of the main heat removal system, leakage of cooling coils, mixing of cooling water with fuel solution, emergency input of positive reactivity, etc.).
Conclusions

• The current FRR system in the Russian Federation ensures sustainable development and updating of the NRI experimental base and is sufficient to regulate the safety of the innovative designs.

• Based on the regulatory experience in the Russian Federation, the IAEA Safety Standards, and positive international experience, including licensing of innovative designs of nuclear installations, the areas for improving the regulatory framework for safety regulation of the nuclear facilities have been outlined.

• The innovative NRIs such as the PIK complex and the MBIR complex would allow the establishment of international centers of excellence based on research reactors.
Thank you for attention!

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